CHROMOSOMAL STUDIES IN THE EGYPTIAN FLORA VI. KARYOTYPE FEATURES OF SOME SPECIES IN SUBFAMILY ASTEROIDEAE (ASTERACEAE)

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Abstract

In this paper, chromosome numbers of 23 species from the flora of Egypt — including four new counts —, distributed in six tribes of subfamily Asteroideae (Asteraceae), are reported. Detailed karyotype features, i. e. chromosome length (MCL) and karyotype asymmetry expressed as arm ratio (MAR), total form percent (TF%), intrachromosomal asymmetry index (A1) and interchromosomal asymmetry index (A2), are described.

Introduction

The Asteraceae are represented in the Egyptian wild flora by 93 genera and 230 species (Täckholm 1974). The family is also represented in the weeds of Egypt by 26 species (Boulos & El-Hadidi 1989).

The Asteraceae show a great array of chromosome numbers. Following Solbrig (1977), numbers vary from as low as n = 2 in *Haplopappus gracilis* (Nutt.) Gray and *Brachycome lineariloba* (DC.) Druce to as high as n = 103 in *Werneria apiculata* Sch. Bip., n = 106 in *Werneria nubigena* Kunth, and n = 110-120 in *Montanoa guatemalensis* Robins. & Greenm. However, the most common basic number in the family is x = 9.

The members of the family in the Egyptian flora have not been a subject of extensive cytological investigations, but Nordenstam (1972) reported chromosome counts from 24 species of Egyptian Asteraceae. Also, chromosome numbers of some species which grow in Egypt are known from chromosome counts in plants from near floras, particularly that of Europe. In the present study, chromosome numbers and detailed karyotype features of 23 Egyptian species belonging to subfamily Asteroideae are reported.

Material and methods

Material of 23 species belonging to six tribes of the subfamily Asteroideae was collected from their natural habitats. The studied species and the localities from which they were collected are given in Table 1. Collectors are in all the cases A. Badr and E. Kamel. Vouchers of the collections are preserved in the herbarium of the Biological Science and Geology Department, Faculty of Education, Ain Shams University (Egypt).

Cytological preparations were carried out on root tips obtained from seeds germinated on sterile moist filter papers in Petri dishes at 20-25°C. Roots were pretreated with 0.05% colchicine solution for 3-4 h and fixed in Carnoy for 24 h and stored in 70% ethanol at 4°C. Cytological preparations were made using the Feulgen squash method and well-spread c-metaphase chromosomes were photographed from temporary preparations at a magnification of 2000x. Slides of the original karyotypes are also preserved in the Laboratory of Cytogenetics of the same department.

A karyogram for each species was constructed by arranging the chromosomes in homologous pairs by order of their length and arm ratio as measured from the photographic prints and the number of chromosome types were determined as described by Levan & al. (1965). Measurements of chromosome lengths were taken on the same photographs of the karyogram. Karyograms are based in one plate.

The variation in chromosome length (MCL) and chromosome arm ratio (MAR) within the karyotype has been estimated by calculating the standard error (SE) of these parameters. Karyotype asymmetry deduced from the ratio between the short arms of the chromosomes and their total length was expressed as total form percent (TF%) as proposed by Huziwara (1962). Karyotype asymmetry expressed by the ratio between the chromosome arms has been also estimated as the intrachromosomal asymmetry index (A1) as suggested by Romero Zarco (1986).

The value of A1 is framed as to be close to zero if all chromosomes are metacentric and near to one if all chromosomes are telocentric. Karyotype asymmetry due to the ratio between size of different chromosomes has been also estimated as the interchromosomal asymmetry index (A2) using Pearson's dispersion coefficient, that is the ratio between the standard deviation and the mean chromosome length (Romero Zarco 1986).

The existence of previous chromosome counts for the studied species has been verified in the indexes of plant chromosome numbers by Fedorov (1969), Goldblatt (1981, 1984, 1985, 1988), Goldblatt & Johnson (1990, 1991, 1994, 1996) and Moore (1971, 1972, 1973, 1974, 1977).

Results and discussion

The cytological features of the 23 investigated species are summarised in Table 1.

Tribe Anthemideae

The chromosome numbers and karyotype description are shown for six species of this tribe. One of them (*Achillea fragrantissima*) is reported for the first time (Table 1). Somatic number of $2n = 2x = 18$ is found in *Achillea fragrantissima*, *Chamomilla recutita* and *Chrysanthemum coronarium*. $2n = 4x = 36$ is recorded in *Achillea santolina* and *Artemisia monosperma*. In *Artemisia judaica*, $2n = 2x = 16$ is recorded. The same chromosome numbers have been reported previously for *Achillea santolina*, *Artemisia judaica*, *Chamomilla recutita* and *Chrysanthemum coronarium*. In this last species both diploid ($2n = 18$) and tetraploid ($2n = 36$) numbers were recorded. Our report of $2n = 36$ in *Artemisia monosperma* differs from that of Nordenstam (1972), who found $2n = 34$ in materials from Egypt.

In the tribe Anthemideae, $x = 9$ seems to be the dominant basic number: it is recorded in five of the six species examined here. Only in *Artemisia judaica* ($2n = 16$) a basic number of $x = 8$ is reported. In the genus *Artemisia*, Fedorov (1969) listed this chromosome number of $x = 8$ in 21 species, whereas $x = 9$ was listed in 123 species of the genus. Vallès (1987) and Oliva & Vallès (1994) confirm that $x = 9$ is dominant in the genus.

The highest MCL (4.20• 0.16•) is recorded in *Chrysanthemum coronarium*, whereas the shortest MCL (1.91 • 0.11•) in *Achillea fragrantissima*. The chromosomes in this tribe are clearly longer than those of other tribes (Table 1).

Karyotypes of the six species include only metacentric and submetacentric chromosomes (Fig. 1, A-F) with close similarity between them in the MAR values: the highest (1.50• 0.09) is recorded in *Artemisia monosperma* and the lowest (1.39• 0.09) in both *Artemisia judaica* and *Chrysanthemum coronarium.* Similar high values of TF% are also found in the examined species of this tribe. The high degree of karyotype symmetry in these species is also indicated by similar A1 and A2 values (Table 1).

Tribe Astereae

The Astereae are represented in this study by *Aster squamatus* and *Conyza linifolia.* Chromosome number of *Aster squamatus* is 2n = 2x = 20, while in *Conyza linifolia* 2n = 6x = 54 is scored. Both numbers were previously recorded. The MCL is 1.48• 0.12• in *Aster squamatus* and 1.02• 0.06• in *C. linifolia.* The latter species has the shortest chromosomes among the species studied (Fig. 1, G and H). *Aster squamatus* has a higher MAR and a lower TF%, as compared to *Conyza linifolia* (Table 1). Both species have similar A1 values, but *Aster squamatus* has considerably higher A2 value (Table 1).

Tribe Calenduleae

In this tribe the chromosome number of *Calendula arvensis* is examined: 2n = 4x = 36. The same number was recorded by other authors. Nevertheless, a very different number of 2n = 44 is reported in other counts. The MCL in *Calendula arvensis* is 1.17• 0.08• and its karyotype is the most symmetric of the studied species: MAR= 1.08• 0.03 and TF%= 48.10. The symmetry of the karyotype of this species (Fig. 2, A) is also indicated by the A1 value (0.07) which is the lowest among the species investigated (Table 1).

Tribe Heliantheae

The karyotypes of five species in this tribe are studied. In the two species of *Xanthium*, i.e. *X. spinosum* and *X. strumarium*, 2n = 4x = 36 is recorded. In *Bidens pilosa*, 2n = 2x = 24 is observed, whereas, in both *Helianthus annuus* and *Verbesina encelioides* the number recorded is 2n = 2x = 34. All our results coincide with previous counts. However, in *B. pilosa* both tetraploid (2n = 48) and hexaploid (2n = 72) numbers were also reported.

The longest chromosomes among the five species of Heliantheae are found in *X. strumarium* (MCL= 2.0• 0.17•), while the shortest (MCL= 1.19• 0.08•) are recorded in *V. encelioides*. The karyotypes of the five species are symmetric (Fig. 2, B-F), being composed of metacentric chromosomes with small variation among them in the MAR. The highest MAR (1.45• 0.05) is recorded in *V. encelioides*, whereas the lowest MAR (1.33• 0.05) is found in *H. annuus*. The low MAR values recorded in the species of Heliantheae are correlated with high values of the TF%. The similarity among the studied species of this tribe in karyotype symmetry is also reflected by similar A1 and A2 values (Table 1).

Tribe Inuleae

The tribe Inuleae is represented here by seven species. Chromosome counts and karyotype descriptions of three of them (*Pulicaria undulata*, *Phagnalon barbeyanum* and *Pluchea dioscoridis*) are presented here for the first time (Table 1). Somatic numbers vary between 2n = 2x = 8 in *Iphiona mucronata* to 2n = 4x = 40 in *Pluchea dioscoridis*. In *Pallenis spinosa* the somatic number is 2n = 2x = 10, whereas in *Pulicaria undulata* 2n = 2x = 12 is recorded. Both in *Inula crithmoides* and *Phagnalon barbeyanum* a diploid number of 2n = 18 is found, while the recorded number for *Filago desertorum* is 2n = 2x = 28. Numbers of *Inula crithmoides*, *Pallenis spinosa* and *Filago desertorum* have been previously scored by other authors. Our result of 2n = 8 in *Iphiona mucronata*, however, differs from a previous count of 2n = 18 by Amin (1972), also on Egyptian material.

The highest MCL among the seven species of Inuleae is found in *Iphiona mucronata* (2.0• 0.14•), whereas the shortest were observed in *Filago desertorum* (1.17• 0.07). The highest MAR value (1.80• 0.15) is recorded in *Pulicaria undulata*, whereas the lowest (1.11• 0.05) was found in *Phagnalon barbeyanum*. The low MAR recorded for the species of this tribe is correlated with high values of the TF% (Table 1), indicating a high degree of karyotype symmetry. The karyotype symmetry in the seven species of Inuleae is also illustrated by the presence of only metacentric and submetacentric chromosomes in the karyotypes of these species (Fig. 3, A-G). However, the A1 and A2 values indicate some degree of karyotype asymmetry in some species. The A1 value ranges between 0.10 in *P. barbeyanum* to 0.43 in *Pulicaria undulata*, whereas the highest A2 (0.24) value is found in *P. spinosa* and the lowest (0.11) in *Inula crithmoides* (Table 1).

Tribe Senecioneae

In the two species of this tribe, i.e. *Senecio aegyptius* and *S. vulgaris*, 2n = 4x = 40 is recorded. The same number has been reported in other previous counts for both species. The chromosomes of the two species are similar in length, MCL is 1.27• 0.09• in *S. aegyptius* and 1.19• 0.04• in *S. vulgaris*. The chromosomes of both species are all metacentric (Fig. 3, H and I) with some differences between them in the MAR, being 1.36• 0.03 for *S. aegyptius* and 1.07• 0.02 for *S. vulgaris*. Differences between these two species in karyotype asymmetry are also reflected in the values of the TF% and are more clearly manifested in the values of A1 and A2, being 0.26 & 0.23 for *S. aegyptius* and 0.16 & 0.12 for *S. vulgaris* respectively (Table 1).

Conclusions

Of the 23 species studied from the Egyptian flora, polyploid numbers are recorded in nine species, distributed in the six tribes (Table 1). It is notable that polyploidization occurs only in species with x = 9 or 10.

With regard to the evolution of the basic chromosome number in Asteraceae, Solbrig (1977) suggested that x = 9 is the ancestral basic chromosome number for all the family. Basic numbers higher than x = 9 should be the result of cycles of polyploidy and successive aneuploid reduction; chromosome numbers lower than x = 9 should be the result of aneuploid reductions. Descending aneuploidy is a general trend in the whole family, as it has been repeteadly pointed out by Stebbins, 1950: 449 & 456, tab. 89, and 1971: 93-96.

As to karyotype symmetry, the calculated TF% of the karyotypes of the examined species ranges between TF%= 35.37 in *Pulicaria undulata* (Inuleae) to TF%= 48.36 in *Senecio vulgaris* (Senecioneae). The values of the TF% for the studied species thus support previous observations (Huziwara 1962, Mehra 1977) that the karyotype in the Asteraceae is symmetric. The intrachromosomal asymmetry index (A1), on the other hand, defines some clear differences between the studied species in the tribes Senecioneae, Inuleae, Heliantheae and Anthemideae. The interchromosomal asymmetry index (A2), however, shows little differences between the studied species.

Measurements of chromosome length indicate that species in tribe Anthemideae have substantially longer chromosomes than those in other tribes. The longest chromosomes are found in *Chrysanthemum coronarium* (MCL= 4.20• 0.16•), whereas the shortest chromosomes are observed in *Conyza linifolia* of tribe

Astereae (MCL= 1.02• 0.06•). In all the studied species, however, small differences in length are recorded among the chromosomes in the karyotype.

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Table 1. Localities and cytological features of the studied taxa. Collectors are A. Badr and E. Kamel; vouchers in Ain-Shams University, Cairo, Egypt. MCL = mean chromosome length. MAR = mean arm ratio. SE= standard error. TF%= total form percent. A1 = intrachromosomal asymmetry index. A2 = interchromosomal asymmetry index. m = metacentric chromosome. M = metacentric point chromosome. sm= submetacentric chromosome. Asterisks indicate new chromosome counts.

Fig. No.	Tribe	Species	Locality	2n	MCL • SE (• m)	MAR• SE	TF%	A1	A2	Chr. Type M	m	sm
1 A	Anthemideae	*Achillea fragrantissima* (Forssk.) Sch. Bip.*	Bir Gindali, 30 km E of Cairo, 7th April, 1995	18	1.91• 0.11	1.45• 0.19	42.91	0.25	0.17	-	8	1
1 B	"	*Achillea santolina* L.	Marakia, 60 km W of Alexandria, 29 th March, 1995	36	3.26• 0.29	1.49• 0.11	40.16	0.30	0.27	-	6	3
1 C	"	*Artemisia judaica* L.	Wadi Feran, South Sinai, 9th April, 1995	16	3.97• 0.19	1.39• 0.09	42.01	0.26	0.13	-	7	1
1 D	"	*Artemisia monosperma* Del.	Cairo-Suez road, 50 km E of Cairo, 24th March, 1995	36	2.56• 0.10	1.50• 0.09	40.21	0.32	0.12	-	7	2
1 E	"	*Chamomilla recutita* (L.) Rausch	Sirs El-Layyan, Menouflya, Nile Delta, 13th May, 1994	18	2.46• 0.09	1.48• 0.15	41.72	0.28	0.11	-	7	2
1 F	"	*Chrysanthemum coronarium* L.	Wadi Habs, Mersa Matruh, 11th April, 1995	18	4.20• 0.16	1.39• 0.09	42.63	0.26	0.11	-	7	2
1 G	Astereae	*Aster squamatus* (Spreng.) Hieron. ex Sod.	Sirs El-Layyan, Menouflya, Nile Delta, 13th May, 1994	20	1.48• 0.12	1.53• 0.16	39.58	0.30	0.27	-	8	2
1 H	"	*Conyza linifolia* (Willd.) Takht.	Sirs El-Layyan, Menouflya, Nile Delta, 13th May, 1994	54	1.02• 0.06	1.48• 0.05	40.81	0.32	0.19	-	9	-
2 A	Calenduleae	*Calendula arvensis* L.	Bourg El-Arab, 50 km W of Alexandria, 29th March, 1995	36	1.17• 0.08	1.08• 0.03	48.10	0.07	0.20	1	8	-
2 B	Heliantheae	*Bidens pilosa* L.	Madinet Nasr, E of Cairo, 15th April, 1995	24	1.51• 0.11	1.35• 0.02	42.77	0.26	0.25	-	12	-

2 C	Heliantheae	*Helianthus annuus* L.	Sirs El-Layyan, Menouflya, 13th May, 1994	34	1.99• 0.08	1.33• 0.05	43.70	0.22	0.20	-	16	1
2 D	"	*Verbesina encelioides* (Cav.) Benth. & Hook. ex A. Gray	Al-Arish, North Sinai, 7th October, 1994	34	1.19• 0.14	1.45• 0.05	40.74	0.30	0.28	-	15	2
2 E	"	*Xanthium spinosum* L.	Sirs El-Layyan, Menouflya, Nile Delta, 13th May, 1994	36	1.66• 0.14	1.36• 0.05	42.55	0.26	0.25	-	9	-
2 F	"	*Xanthium strumarium* L.	Sirs El-Layyan, Menouflya, Nile Delta, 13th May, 1994	36	2.00• 0.17	1.36• 0.09	42.26	0.24	0.25	-	8	1
3 A	Inuleae	*Filago desertorum* Pomel	Cairo-Suez road, 50 km E of Cairo, 24th March, 1995,	28	1.17• 0.07	1.48• 0.06	40.43	0.31	0.21	-	11	3
3 B	"	*Inula crithmoides* L.	Al Bocela, Rasheed, Alexandria road, 30th March, 1995	18	1.40• 0.05	1.27• 0.08	44.26	0.19	0.11	-	8	1
3 C	"	*Iphiona mucronata* (Forssk.) Asch. & Schweinf.	Bir Gindali, 30 km E of Cairo, 7th April, 1995	8	2.00• 0.14	1.39• 0.14	42.18	0.25	0.14	1	3	-
3 D	"	*Pallenis spinosa* (L.) Cass.	Wadi Habs, Mersa Matruh, 11th April, 1995	10	1.64• 0.18	1.52• 0.12	39.42	0.33	0.24	-	4	1
3 E	"	*Pulicaria undulata* (L.) Kostel*	Wadi Natrun, 110 km Cairo-Alexandria road, 24th April, 1995	12	1.81• 0.17	1.80• 0.15	35.57	0.43	0.23	-	3	3
3 F	"	*Phagnalon barbeyanum* Asch. & Schweinf.*	Wadi Natrun, 100 km Cairo-Alexandria road, 24th April, 1995	18	1.39• 0.07	1.11• 0.04	47.24	0.10	0.15	-	8	-
3 G	"	*Pluchea dioscoridis* (L.) DC.*	Sirs El-Layyan, Menouflya, Nile Delta, 13th May, 1994	40	1.89• 0.08	1.34• 0.05	42.90	0.24	0.14	-	10	-
3 H	Senecioneae	*Senecio aegyptius* L.	Cairo-Suez road, 50 km E of Cairo, 24th March, 1995	40	1.27• 0.09	1.36• 0.03	42.41	0.26	0.23	-	10	-
3 I	"	*Senecio vulgaris* L.	Sirs El-Layyan, Menouflya, Nile Delta, 13th May, 1994	40	1.19• 0.04	1.07• 0.02	48.36	0.16	0.12	1	9	-

Figure captions

Figure 1. Karyograms of A) *Achillea fragrantissima*; B) *Achillea santolina*; C) *Artemisia judaica*; D) *Artemisia monosperma*; E) *Chamomilla recutita*; F) *Chrysanthemum coronarium*; G) *Aster squamatus*; H) *Conyza linifolia.*

Figure 2. Karyograms of A) *Calendula arvensis*; B) *Bidens pilosa*; C) *Helianthus annuus*; D) *Verbesina encelioides;* E) *Xanthium spinosum;* F) *Xanthium strumarium.*

Figure 3. Karyograms of A) *Filago desertorum*; B) *Inula crithmoides*; C) *Iphiona mucronata;* D) *Pallenis spinosa;* E) *Pulicaria undulata*; F) *Phagnalon barbeyanum;* G) *Pluchea dioscoridis*; H) *Senecio aegyptius*; I) *Senecio vulgaris.*

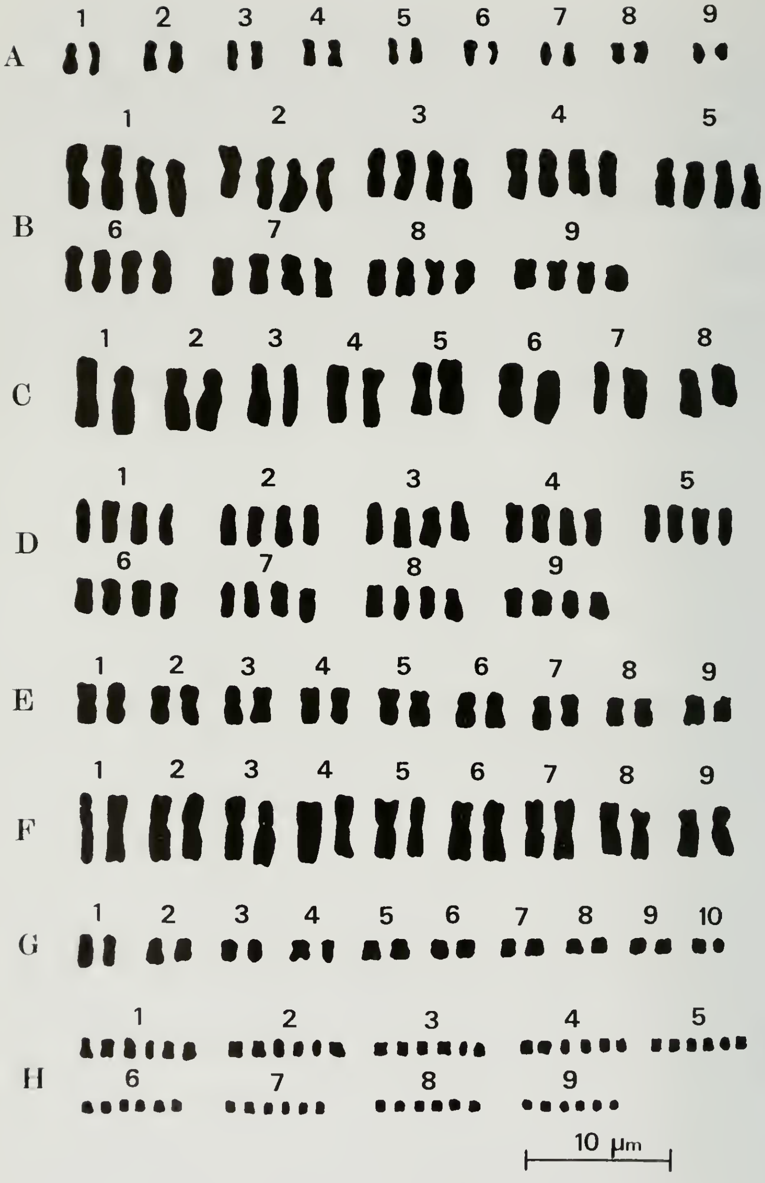

Fig. 1.

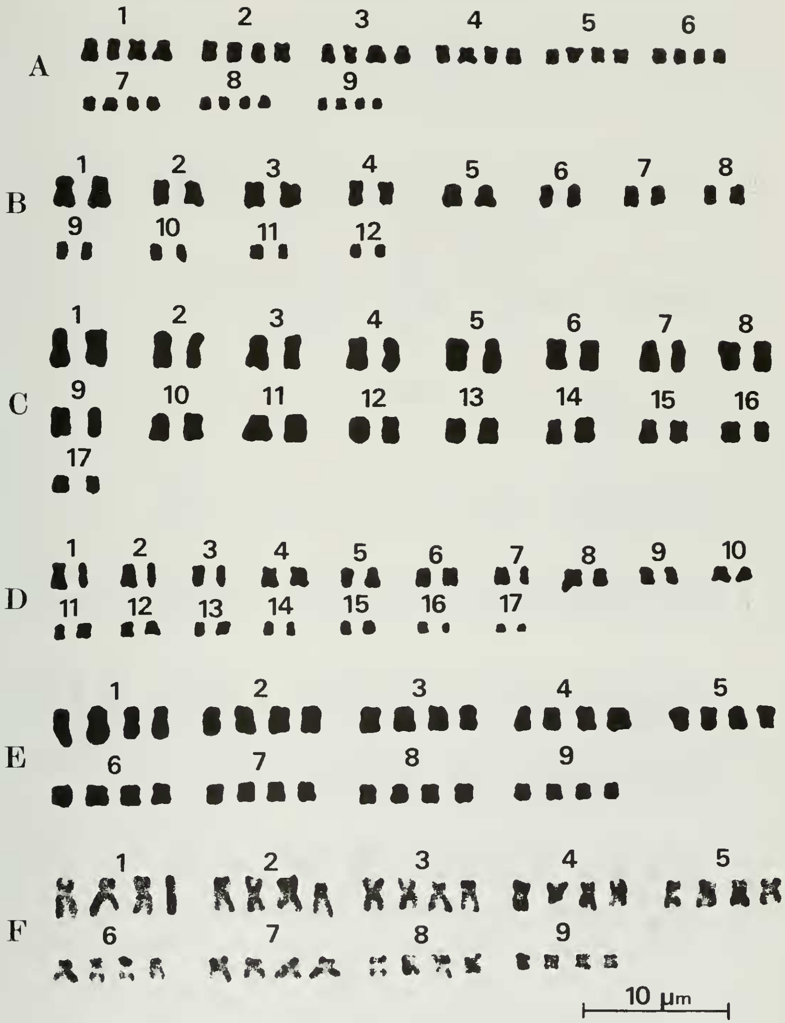
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Fig. 2.

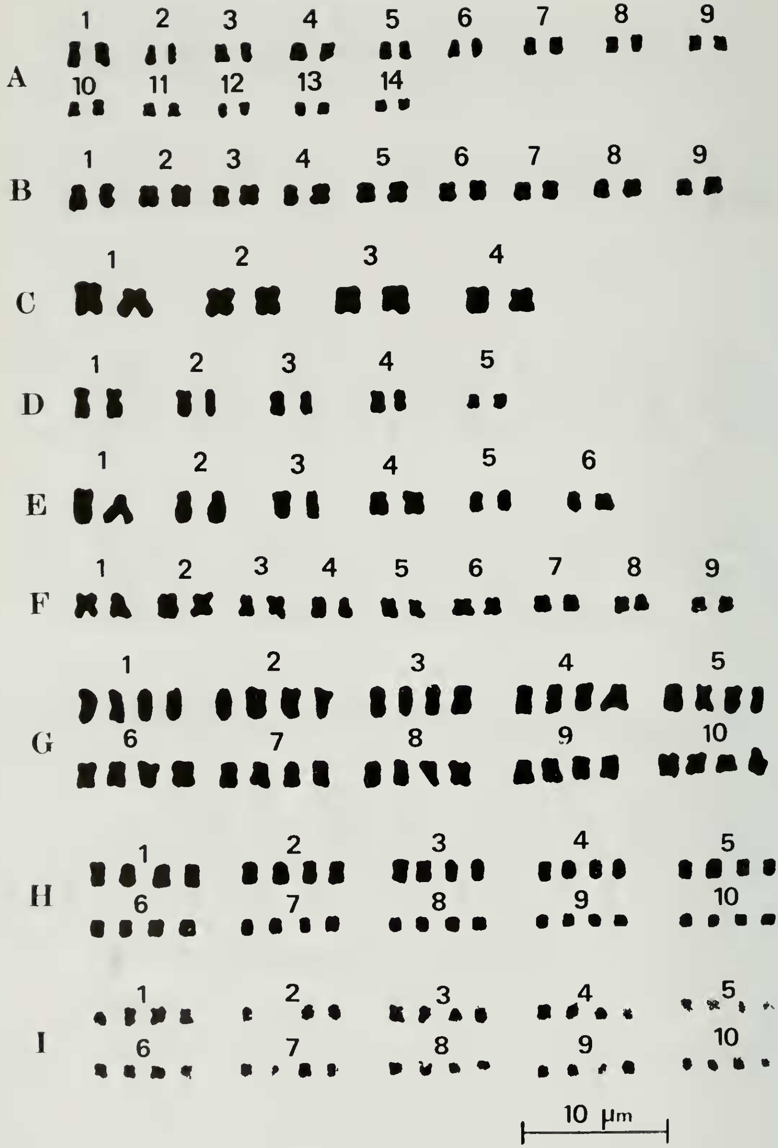
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Fig 3.